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iAP20 Rec'd PCT/EP 12 JUN 2006

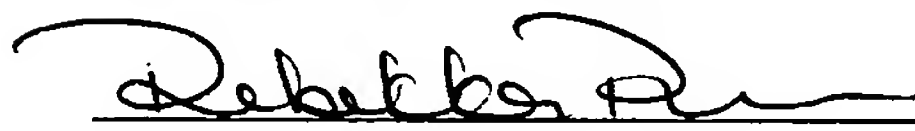
Docket No.: 2003P13373

CERTIFICATION

I, the below named translator, hereby declare that: my name and post office address are as stated below; that I am knowledgeable in the English and German languages, and that I believe that the attached text is a true and complete translation of PCT/EP2004/053317, filed with the European Patent Office on December 7, 2004.

I hereby declare that all statements made herein of my own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issued thereon.

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1 Description

2

3 Control unit and control device comprising the control unit

4

5 The invention relates to a control unit and a control device
6 comprising the control unit. Such a control unit or such a
7 control device is configured to activate a sensor resistor.

8 They are used in particular to detect the oil level of an
9 internal combustion engine of a motor vehicle.

10

11 If a motor vehicle, in which an internal combustion engine
12 is disposed, is not equipped with an oil level sensor, the
13 owner of the vehicle must check at regular intervals whether
14 their vehicle is filled with an adequate quantity of engine
15 oil. An oil level sensor can be used to ensure that the
16 driver does not have to use a dipstick to check the oil
17 level in the motor vehicle at regular intervals, which is on
18 the one hand more user-friendly and on the other hand
19 ensures that the owner of the vehicle is informed when the
20 oil level is too high or too low and can then top up or
21 drain the engine oil accordingly. Motor vehicle
22 manufacturers can protect themselves against unjustified
23 warranty claims based on too low an oil level by registering
24 the measured values of the oil level sensor accordingly.

25

26 The sensor element of the oil level sensor can be a wire,
27 which is disposed in an oil pan of the internal combustion
28 engine between two supports such that the oil level can be
29 concluded from the proportion of the total length of the
30 wire that is in the oil. The oil level is then determined by
31 means of an electro-thermal measuring principle.

32

1 Depending on the oil level there is oil round a varying
2 length of the wire, the remainder of the wire being in a
3 gaseous medium, preferably air. If a current is passed
4 through the wire, the electrical power in the wire is
5 converted to heat. This heat is given off to the medium
6 surrounding the wire. The electro-thermal measuring
7 principle makes use of the fact that the heat conductivity
8 values of engine oil and air are very different and the
9 electrical resistance of the wire is temperature-dependent.
10 The thermal transfer resistance from wire to oil is
11 significantly lower than from wire to air. This means that
12 the part of the wire in the engine oil is cooled much more
13 efficiently and therefore gives off heat more effectively
14 than the part in air.

15
16 With regard to the electro-thermal measuring principle, it
17 is known that a predefined current can be passed through the
18 wire for a predefined time period, causing the wire and its
19 surroundings to be heated. This causes the value of the
20 resistance of the wire to change as a function of the
21 current oil level over the predefined time period. Depending
22 on the voltages, which drop at the measuring wire when the
23 current is first passed and at the end of the predefined
24 time period, it is known that the oil level can be
25 determined from a set of characteristics. The power loss
26 that is converted in the wire during the predefined time
27 period of current passage is highly dependent on the
28 temperature of the wire when the current is first passed and
29 therefore also the ambient temperature. This means that
30 sensitivity is very much a function of ambient temperature.

31
32 A mechanism for improving the accuracy of a sensing resistor
33 for an NTC resistor used as a temperature sensor is known

1 from WO 91/08441. It comprises a circuit arrangement with a
2 network of resistors. A computing mechanism influences the
3 network of resistors such that the measuring range for the
4 NTC resistor is displaced. The overall resistance is changed
5 to this end.

6
7 The object of the invention is to create a control unit and
8 a control device comprising the control unit, which are
9 simple and can be adjusted in a precise manner by means of
10 the one power loss in a sensor resistor.

11
12 The object is achieved by the features of the independent
13 claims. Advantageous embodiments of the invention are
14 characterized in the subclaims.

15
16 In respect of the control unit the invention is
17 characterized by a control unit with a voltage source and a
18 reference resistor, which can be connected in the required
19 manner in series with a sensor resistor, the value of which
20 is a function of its temperature. The control unit is
21 configured such that in the connected state the output
22 voltage of the voltage source drops at the sensor resistor
23 and the reference resistor. The reference resistor is
24 dimensioned such that the maximum power loss of the sensor
25 resistor is in the required value range of the sensor
26 resistor.

27
28 As far as the control device is concerned, the invention is
29 characterized by the control device comprising the control
30 unit and an evaluation unit, which is configured to generate
31 a control signal.

32

1 Both the claimed control unit and the claimed control device
2 have the advantage that while a voltage is being applied to
3 the sensor resistor by the voltage source, the power loss
4 that is converted in the sensor resistor remains
5 approximately identical within the required value range of
6 the sensor resistor. This means that when the electro-
7 thermal measuring principle is applied, the sensitivity is
8 almost independent of the temperature of the sensor resistor
9 when voltage is first applied to the sensor resistor.

10
11 In one advantageous embodiment of the control unit the
12 voltage source is configured to amplify the input voltage.
13 This has the advantage that the output voltage of the
14 voltage source can be greater than its maximum input
15 voltage. It is thus possible to modify the power loss that
16 is converted in the sensor resistor to a high value in a
17 simple manner.

18
19 The object is achieved by the features of the independent
20 claims. Advantageous embodiments of the invention are
21 characterized in the subclaims.

22
23 In respect of the control unit the invention is
24 characterized by a control unit with a voltage source and a
25 reference resistor, which can be connected in series with a
26 sensor resistor, the value of which is a function of its
27 temperature. The control unit is configured such that in the
28 connected state the output voltage of the voltage source
29 drops at the sensor resistor and the reference resistor. The
30 reference resistor is dimensioned such that the maximum
31 power loss of the sensor resistor is in the required value
32 range of the sensor resistor.

1 As far as the control device is concerned, the invention is
2 characterized by a control device comprising the control
3 unit and an evaluation unit, which is configured to generate
4 a control signal.

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12 thermal measuring principle is applied, the sensitivity is
13 almost independent of the temperature of the sensor resistor
14 when voltage is first applied to the sensor resistor.

15
16 In one advantageous embodiment of the control unit the
17 voltage source is configured to amplify the input voltage.
18 This has the advantage that the output voltage of the
19 voltage source can be greater than its maximum input
20 voltage. It is thus possible to adjust the power loss that
21 is converted in the sensor resistor to a high value in a
22 simple manner, thereby allowing the sensor resistor to give
23 off a large amount of heat to its surroundings. A change in
24 the sensor resistor can thus be enhanced, thereby increasing
25 the sensitivity of the measurement.

26
27 In a further advantageous embodiment of the control unit the
28 voltage source has a limiter for the output voltage. It can
29 thus be ensured in a simple manner that the sensor resistor
30 is not damaged if the voltage source is activated
31 incorrectly. The limiter can be configured as a Zener diode
32 in a particularly simple manner.

1 In a further advantageous embodiment of the control unit the
2 voltage source comprises three transistors with a common
3 emitter. The first transistor is connected such that its
4 base current is a function of a control signal, which can be
5 applied to the control unit. The base of the second
6 transistor is connected to the collector of the first
7 transistor and the base of the third transistor is connected
8 to the collector of the second transistor. This has the
9 advantage that the voltage source is intrinsically safe. In
10 other words if the voltage source is not activated, the
11 output voltage of the voltage source is zero.

12
13 In a further advantageous embodiment of the control unit a
14 low-pass filter is disposed between the first and second
15 transistors of the voltage source. This allows a high direct
16 component to be achieved in the output voltage of the
17 voltage source in a simple manner, even if the input voltage
18 of the voltage source has a high alternating component.

19
20 In a further advantageous embodiment of the control unit the
21 low-pass filter is formed by a capacitor, which is connected
22 to the collectors of the first and second transistors, a
23 resistor, which is connected both to the collector of the
24 first transistor and to a voltage supply of the voltage
25 source, and a further resistor, which is connected both to
26 the collector of the second transistor and to the voltage
27 supply of the voltage source. Such a low-pass filter is
28 characterized by its simplicity.

29
30 In a further advantageous embodiment of the control unit the
31 reference resistor is connected both to the output of the
32 voltage source and to the sensor resistor. This has the
33 advantage that the voltage source is able to withstand a

1 short circuit when the sensor resistor short circuits to
2 ground.

3

4 In a further advantageous embodiment the control unit is
5 configured such that it outputs a variable characterizing
6 the voltage drop at the sensor resistor and the reference
7 resistor at a first output and that it outputs a variable
8 characterizing the potential between the sensor resistor and
9 the reference resistor at a second output. This
10 configuration allows very precise determination of the value
11 of the sensor resistor as errors are eliminated when
12 adjusting the voltage that drops at the sensor resistor and
13 the reference resistor and in the case of an analog-digital
14 conversion of the characterizing variables in the evaluation
15 unit, errors due to fluctuations in the supply voltage of
16 the analog-digital converter(s), which is at the same time
17 the reference voltage of the analog-digital converter(s),
18 are eliminated.

19

20 In a further advantageous embodiment of the control unit a
21 voltage divider is provided, to which the voltage drop at
22 the sensor resistor and the reference resistor is applied on
23 the input side and which is connected to the first output on
24 the output side. A reduced voltage is therefore output at
25 the first output, corresponding to the division ratio of the
26 voltage divider. Appropriate dimensioning of the voltage
27 divider allows the converter range of an analog-digital
28 converter to be utilized as fully as possible and it can
29 also be ensured that the voltage present at the first output
30 is not greater than the supply voltage of the analog-digital
31 converter.

32

1 In a further advantageous embodiment of the control unit a
2 switch is provided, which is used to control whether the
3 voltage drop at the sensor resistor and the reference
4 resistor is applied to the voltage divider on the input side
5 or a supply voltage of the evaluation unit. If the control
6 device is equipped with such a control unit, the actual
7 voltage divider ratio can be determined precisely by
8 controlling the switch to the position, in which the supply
9 voltage of the evaluation unit is present on the input side
10 of the voltage divider. This means that manufacturing,
11 temperature and age-induced fluctuations in the values of
12 the voltage divider resistors can be compensated for in a
13 simple manner.

14
15 In one advantageous embodiment of the control device the
16 evaluation device has a regulator, the regulated variable of
17 which is the voltage drop at the sensor resistor and the
18 reference resistor and the actuating signal of which is the
19 control signal. This means that the output voltage of the
20 voltage source can be adjusted even more accurately. If the
21 evaluation unit is a microcontroller, the control signal can
22 be pulse-width modulated very simply.

23
24 Exemplary embodiments of the invention are described below
25 with reference to the schematic drawings, in which:

26
27 Figure 1 shows a control device comprising a control unit,

28
29 Figure 2 shows a flow diagram of a program for determining
30 an oil level,

31
32 Figure 3 shows a flow diagram of a program providing a
33 regulator,

1 Figure 4 shows a further embodiment of the control device
2 and

3
4 Figure 5 shows the pattern of different variables over
5 values of the sensor resistor R_{sens} .

6
7 Elements with the same structure and function are marked
8 with the same reference characters in all the figures.

9
10 A control device (Figure 1) comprises a control unit 1 and
11 an evaluation unit 3. It is also assigned a first voltage
12 supply 4, which is preferably the vehicle electrical system
13 voltage supply where the control device is being used for an
14 internal combustion engine of a motor vehicle, said vehicle
15 electrical system voltage supply being supplied by the
16 vehicle battery and a generator. The control device also
17 comprises a second voltage supply 5, which transforms and
18 preferably adjusts the vehicle electrical system voltage
19 V_{bat} to a supply voltage VCC of the evaluation unit 3. The
20 vehicle electrical system voltage V_{bat} is generally 12 V,
21 while the supply voltage VCC of the evaluation unit 3 is
22 generally 5 V. The evaluation unit 3 is preferably
23 configured as a microcontroller.

24
25 The control unit 1 can be configured separately from the
26 evaluation unit 3 and the second voltage supply 5. It can
27 for example be configured on a chip as an integrated
28 circuit. The control device is preferably part of an engine
29 control device, to which different further measured
30 variables, e.g. an air mass flowing through the intake tract
31 of the internal combustion engine, the position of a gas
32 pedal or even the current air/fuel ratio are received. As a
33 function of these measured variables the engine controller

1 then determines actuating signals for the actuators of the
2 internal combustion engine, which are for example a throttle
3 valve or an injection valve.

4
5 The control unit 1 has a control input 11, to which a
6 control signal CTRL can be applied, which is generated in
7 the evaluation unit 3, said control input 11 being connected
8 to the input of a first low-pass filter 14.

9
10 The control unit also has a first and second output 12, 13,
11 which are connected to an analog-digital converter 31 of the
12 evaluation unit.

13
14 In a simple embodiment the first and second outputs 12, 13
15 of the control unit 1 are connected via a multiplexer to a
16 single analog-digital converter 31. The outputs are however
17 each preferably connected to their own analog-digital
18 converter 31. This has the advantage that the voltages
19 present at the terminals 12 and 13 can undergo analog-
20 digital conversion at the same time. The analog-digital
21 converter(s) 31 has/have a conversion range, which
22 corresponds to the supply voltage VCC of the evaluation unit
23 3.

24
25 The first low-pass 14 comprises resistors R4a, R4b and a
26 capacitor C4. The first low-pass 14 is connected on the
27 output side to the base of a first transistor Q1 of a
28 voltage source 15. A resistor R3 is also provided, which is
29 connected both on the output side to the low-pass and to the
30 base of the first transistor Q1 and also to ground GND. The
31 resistor R3 causes the first transistor Q1 to remain
32 disconnected when there is no control signal CTRL.

1 The voltage source 15 comprises the first transistor Q1, a
2 second transistor Q2, a third transistor Q3, a second low-
3 pass filter 16 and a Zener diode D2. The emitter of the
4 first transistor Q1 is connected to ground GND. The
5 collector of the first transistor Q1 is connected both to
6 the base of a second transistor Q2 and to a second low-pass,
7 via which it is connected to the first voltage supply 4 and
8 thus to the vehicle electrical system voltage Vbat.

9
10 The emitter of the second transistor Q2 is connected to
11 ground GND and its collector is connected both to the base
12 of a third transistor Q3 and to the second low-pass 16 and
13 via this to the first voltage supply 4 and thus to the
14 vehicle electrical system voltage Vbat.

15
16 The anode of the Zener diode D2 is connected to ground GND
17 and its cathode is connected to the base of the third
18 transistor Q3. The collector of the third transistor Q3 is
19 connected to the cathode of a protective diode D1, the anode
20 of which is connected to the first voltage supply 4 and thus
21 to the vehicle electrical system voltage Vbat. The emitter
22 of the third transistor Q3 forms an output 17 of the voltage
23 source 15.

24
25 The output 17 of the voltage source 15 is connected both to
26 a first terminal for a sensor resistor Rsens and to a
27 voltage divider on the input side. The voltage divider
28 comprises a resistor 7a and 7b. A capacitor C1 is connected
29 parallel to the resistor 7b. The first output 12 is
30 connected to the connecting line between the resistor R7a
31 and the resistor R7b. The capacitor C1 brings about voltage
32 stabilization at the first output 12. A second terminal 19
33 for the sensor resistor Rsens is connected to a reference

1 resistor Rref, which is also connected to ground GND. The
2 reference resistor Rref is preferably a so-called shunt
3 resistor. Such shunt resistors have relatively low ohmic
4 values of 1 m Ω up to around 100 Ω and a high current carrying
5 capacity of 1 mA up to 100 A.

6
7 The second terminal 19 is also connected to a resistor R8,
8 which is connected to the second output 13 of the control
9 unit 1 and to a capacitor C2, which in turn is connected to
10 ground GND. The resistor R8 is configured to be high-
11 resistance and preferably has a value from 3 to 8 k Ω . The
12 capacitor C2 is used for voltage stabilization at the second
13 output 13.

14
15 The sensor resistor Rsens is preferably a resistance wire,
16 which is disposed vertically in an oil pan of the internal
17 combustion engine. That is to say the resistance wire is
18 disposed in the oil pan such that the proportion of the
19 resistance wire in the oil is a measure of the oil level of
20 the internal combustion engine. During the required
21 operation of the control device the sensor resistor Rsens is
22 connected to the first and second terminals 18, 19.

23
24 If there is a high potential present at the base of the
25 first transistor Q1, for example the supply voltage VCC of
26 the evaluation unit 3 minus a corresponding voltage drop at
27 the resistors R4a and R4b, the first transistor Q3 is at
28 saturation, that is to say ground GND is almost present at
29 its collector. Almost the entire vehicle electrical system
30 voltage Vbat then drops at the resistor R2. The second
31 transistor Q2 is correspondingly blocked. In the stationary
32 state the vehicle electrical system voltage Vbat is present
33 at the collector of the second transistor or, if the vehicle

1 electrical system voltage Vbat is greater than the breakdown
2 voltage of the Zener diode D2, the breakdown voltage of the
3 Zener diode D2 is present at the collector of the second
4 transistor Q2. Therefore the vehicle electrical system
5 voltage Vbat or the breakdown voltage of the Zener diode D2
6 is also present at the base of the third transistor Q3. In
7 this instance the vehicle electrical system voltage Vbat
8 minus the base emitter voltage of the third transistor Q3 or
9 the breakdown voltage of the Zener diode D2 also minus the
10 base emitter voltage of the third transistor Q3 is present
11 at the output 17 of the voltage source 15.

12

13 The Zener diode D2 ensures that the output voltage of the
14 voltage source 15 does not exceed the breakdown voltage of
15 the Zener diode D2 minus the base emitter voltage of the
16 third transistor. By defining the breakdown voltage of the
17 Zener diode D2 correspondingly it is thus possible to adjust
18 the maximum output voltage present at the output 17 of the
19 voltage source 15. This ensures in a simple manner that
20 circuit elements connected downstream are not damaged in the
21 event of a fault.

22

23 The diode D1 protects the voltage source 15 against polarity
24 reversal of the first voltage supply 4.

25

26 If however the control signal CTRL has a low level, for
27 example that of ground GND, the first transistor Q1 also
28 blocks in stationary mode, with the result that the base of
29 the second transistor Q2 receives approximately all the
30 current flowing through the resistor R2, as a result of
31 which the second transistor Q2 is conductive and at
32 saturation. This in turn means that the third transistor Q3

1 blocks. In this instance ground GND is present as potential
2 at the output 17 of the voltage source 15.

3

4 If however a voltage passed via the resistors R4a, R4b is
5 present at the base of the first transistor Q1, the
6 potential of said voltage being between the two extremes
7 described above, the transistor Q1 is operated in
8 proportional mode and the transistor Q2 is also operated in
9 proportional mode in reverse proportion to the transistor
10 Q1. The third transistor Q3 is operated in proportional
11 mode. Its emitter voltage follows the collector voltage of
12 the second transistor Q2 minus its base emitter voltage. The
13 output voltage at the output 17 of the voltage source 15 can
14 in this instance thus be varied continuously and thus
15 adjusted.

16

17 A second low-pass 16 smoothes the base voltage of the third
18 transistor Q3, thereby reducing the alternating component of
19 the output voltage, which is present at the output 17 of the
20 voltage source 15.

21

22 If an additional resistor (not shown) is provided, which is
23 both connected to the base of the third transistor Q3 and is
24 also connected to the cathode of the Zener diode and the
25 collector of the second transistor Q2, it can be ensured by
26 dimensioning said resistor appropriately that the third
27 transistor Q3 is not damaged in the event of a short circuit
28 at the output 17 of the voltage source 15. Alternatively the
29 protective diode D1 can also be disposed between the emitter
30 of the third transistor Q3 and the output 17 of the voltage
31 source 15.

32

1 The transistors Q1 to Q3 of the voltage source 15 are
2 preferably integrated monolithically. This results in a
3 particularly appropriate set of characteristics for the
4 transistors Q1, Q2, Q3 and more even temperature
5 distribution in the transistors Q1 to Q3.

6
7 A program (Figure 2) for determining an oil level L_OIL of
8 the engine oil in the internal combustion engine is started
9 in a step S1. It preferably starts at approximately the same
10 time as the internal combustion engine, as the oil is
11 distributed in the internal combustion engine and its level
12 in the oil pan sinks as time continues to pass after the
13 start time. An informative oil level measurement is
14 therefore simply effected very close to the time when the
15 internal combustion engine starts up.

16
17 Also - starting in step S1 - a control signal CTRL is
18 generated for a predefined time period, e.g. 600 ms. The
19 subsequent steps of the program are processed parallel to
20 the generation of the control signal CTRL. The control
21 signal CTRL is preferably generated by means of a regulator,
22 which is described in more detail below with reference to
23 the flow diagram in Figure 3. The control signal CTRL is
24 preferably pulse-width modulated. In a simple embodiment of
25 the control device however the regulator can be omitted and
26 the control signal CTRL need only be output for the
27 predefined time period with a voltage level of the supply
28 voltage VCC of the evaluation unit 3. In this instance the
29 resistors R4a, R4b and R3 must then be correspondingly
30 dimensioned, such that the required voltage is present at
31 the base of the first transistor Q1.

1 The output voltage present at the output 17 of the voltage
2 source is preferably between 6 and 8 volts maximum.

3

4 In a step S2 the analog-digital converter(s) 31 is/are used
5 to determine digital values ADC_A1, ADC_A2 of the voltages
6 present at the first and second outputs 12, 13. Almost the
7 entire converter range of the analog-digital converter(s) 31
8 can be utilized in conjunction with appropriate dimensioning
9 of the resistors R7a and R7b of the voltage divider and the
10 reference resistor Rref.

11

12 In a step S3 the value of the sensor resistor Rsens at time
13 t0 is then determined as a function of the value of the
14 reference resistor Rref, the resistors R7a and R7b and the
15 digital values ADC_A1, ADC_A2 of the voltages at the first
16 and second output 12, 13. By determining the value of the
17 resistor Rsens as a function of the relationship of the
18 digital values ADC_A1 and ADC_A2 of the voltages at the
19 first and second output 12, 13, fluctuations of the supply
20 voltage VCC of the evaluation unit 3 do not affect the value
21 of the sensor resistor Rsens.

22

23 The program is then continued in a step S5, in which it is
24 verified whether the current time t is greater than or equal
25 to the time t0 plus a predefined delay time period dt. If
26 the condition of step S5 is not satisfied, the program
27 remains at step S7 for a predefined waiting time period T_W,
28 which is shorter than the delay time period dt. If however
29 the condition of step S5 is satisfied, the program branches
30 to a step S9. The delay time period dt and the waiting time
31 period T_W are preferably selected such that the step S9 is
32 processed in a time t1 which is delayed by the predefined

1 time period for the presence of the second control signal
2 CTRL2 at time t0. This time period is approximately 600 ms.

3
4 In step S9 the analog-digital converter(s) 31 is/are used
5 again to determine the digital values ADC_A1 and ADC_A2 of
6 the voltages at the first output 12 and the second output
7 13. The time sequences of the steps S5, S7 and S9 are
8 selected such that the control signal CTRL is still being
9 generated at the time when step S9 is being processed.

10
11 In a step S11 the value of the sensor resistor at time t1 is
12 determined from the digital values ADC_A1 and ADC_A2
13 determined in step S9, the reference resistor Rref and the
14 values of the resistors R7a and R7b.

15
16 In a subsequent step S13 the oil level L_OIL is determined
17 as a function of the values of the sensor resistor Rsens at
18 times t0 and t1 as determined in steps S3 and S11. This is
19 preferably done using a set of characteristics, which was
20 determined previously by means of corresponding tests and
21 measurements. The program is then terminated in a step S15.

22
23 The evaluation unit 3 preferably also comprises a regulator,
24 which is deployed in the form of a program. The program is
25 stored in the evaluation unit 3 and downloaded for the
26 operation of the evaluation unit 3 and processed at regular
27 intervals. The program is preferably processed parallel to
28 the processing of steps S1 to S9 according to the program in
29 Figure 2.

30
31 In a step S20 (Figure 3) the program is started and
32 variables are optionally initialized. In a step S22 the

1 digital value ADC_A1 of the voltage at the first output 12
2 is determined.

3
4 In a step S24 an actual value U_REF_AV of the voltage, which
5 drops at the reference resistor Rref and the sensor resistor
6 Rsens, is determined as a function of the digital value
7 ADC_A1, the maximum value ADC_A1_MAX of the digital value
8 ADC_A1 of the supply voltage VCC of the evaluation unit 4
9 and the reverse voltage divider ratio of the voltage
10 divider.

11
12 In a step S26 a target value U_REF_SP is determined of the
13 voltage, which drops over the sensor resistor Rsens and the
14 reference resistor Rref.

15
16 In a step S28 the control signal is generated as a function
17 of the determined target value and actual value of the
18 voltage drop at the sensor resistor Rsens and the reference
19 resistor Rref. The control signal CTRL is preferably pulse-
20 width modulated, the pulse width being a function of the
21 difference between the target value U_REF_SP and the actual
22 value U_REF_AV. It is possible in this manner to regulate
23 the output voltage very precisely at the output 17 of the
24 voltage source 15.

25
26 In an alternative embodiment of the control device (Figure
27 4) the reference resistor Rref is connected both to the
28 output 17 of the voltage source 15 and to the first terminal
29 18 for the sensor resistor Rsens. The second terminal 19 for
30 the sensor resistor Rsens is connected directly to ground
31 GND. This circuit arrangement has the advantage compared
32 with the one in Figure 1 that due to the arrangement of the
33 reference resistor Rref it is resistant to short circuits

1 when the sensor resistor Rsens short circuits to ground GND.
2 With this embodiment of the control device it is therefore
3 possible optionally to omit the resistor between the cathode
4 of the Zener diode D2 and the base of the third transistor
5 Q3.

6
7 Figure 5 shows patterns of different variables over the
8 value range of the sensor resistor Rsens in the event that
9 the output voltage at the output 17 of the voltage source 15
10 is 6 volts and the reference resistor has a value of 10 Ω .
11 The required value range of the sensor resistor Rsens is
12 thereby between 17 and 37 Ω for example. A curve 91
13 represents the pattern of the voltage drop at the sensor
14 resistor Rsens. A curve 92 represents the current through
15 the sensor resistor Rsens. A curve 93 represents the power
16 loss in the sensor resistor Rsens. By comparison a curve 94
17 shows the power loss in the sensor resistor Rsens, when
18 there is a constant current regulator present instead of the
19 voltage regulator. The curve 91 is scaled in respect of the
20 right ordinates. The curves 92, 93 and 94 are scaled in
21 respect of the left ordinates.

22
23 It can be seen from the curve 93 of the power loss in the
24 sensor resistor Rsens that its maximum is within the
25 required value range of the sensor resistor Rsens and that
26 the pattern of the curve in this range is extremely flat,
27 almost horizontal. The power loss in the sensor resistor is
28 thus almost constant in the required value range of the
29 sensor resistor Rsens. This means that irrespective of the
30 temperature of the sensor resistor Rsens at the start of the
31 application of voltage to the sensor resistor Rsens, an
32 approximately identical heat is converted in the sensor
33 resistor Rsens within the predefined time period. The

1 sensitivity of the oil level measurement is therefore almost
2 independent of the start temperature.

3

4 The voltage divider, formed by the resistors R7a and R7b, is
5 preferably connected on the input side to a switch 19a,
6 which connects the voltage divider as a function of its
7 switch position either to the first terminal 17 of the
8 sensor resistor Rsens or to the second voltage supply 5 and
9 therefore the supply voltage VCC of the evaluation unit 3.

10 Thus by corresponding detection of the digital value ADC_A1
11 of the voltage at the first output 12, when the switch 19
12 connects the input of the voltage divider to the second
13 voltage supply 5, it is possible to determine the actual
14 voltage divider ratio of the resistors R7a and R7b and take
15 it into account when determining the value of the sensor
16 resistor Rsens in steps S3 and S11 of the program according
17 to Figure 2. It is thus possible to increase the accuracy of
18 the determination of the value of the sensor resistor Rsens
19 in steps S3 and S11 further in this manner.

20

21 The accuracy of the determination of the value of the sensor
22 resistor Rsens can also be further increased by measuring
23 the reference resistor Rref individually when producing the
24 control device and storing the value of the reference
25 resistor thus determined in the evaluation unit 3.

26

27 The sensor resistor Rsens is preferably configured as a
28 resistance wire but it can also be in the form of any other
29 resistor, to which a power that has to be adjusted precisely
30 is to be fed. The transistors can also be field effect
31 transistors, in particular MOS-FET transistors.

32

1 It is possible to identify an error using the digital
2 value(s) ADC_A1, ADC_A2 by means of plausibilization and to
3 adjust the control signal CTRL such that a predefined
4 potential, preferably ground, is present at the output 17 of
5 the voltage source 15.

6